Tevatron Electron Lens Activities

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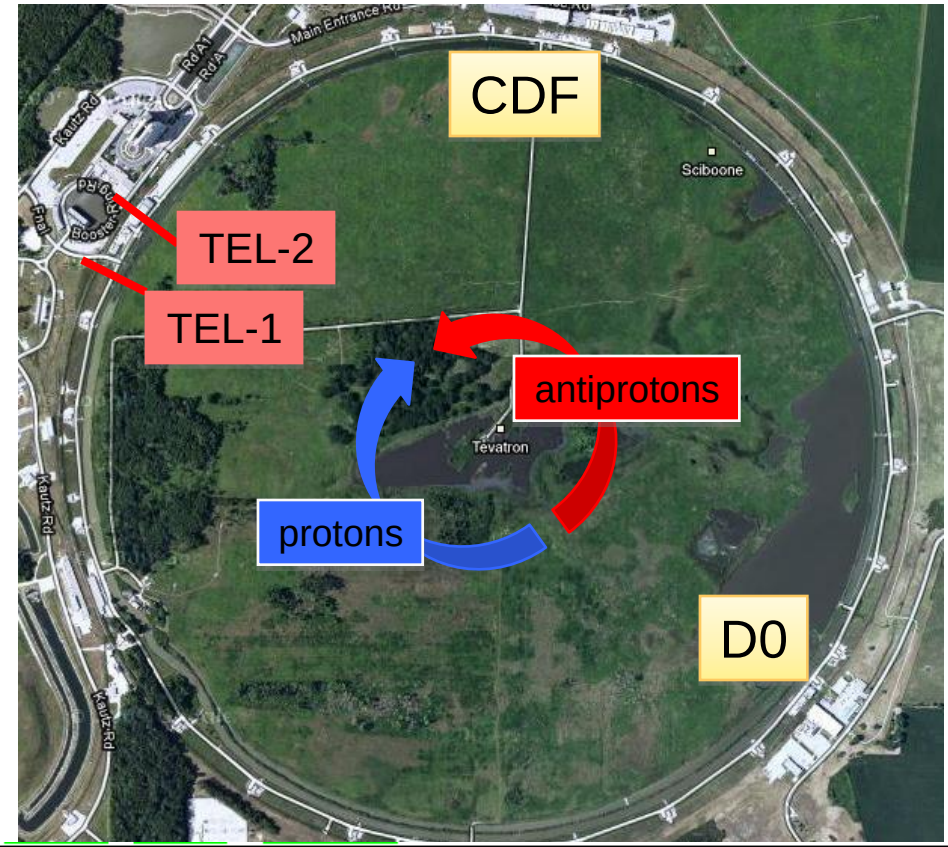
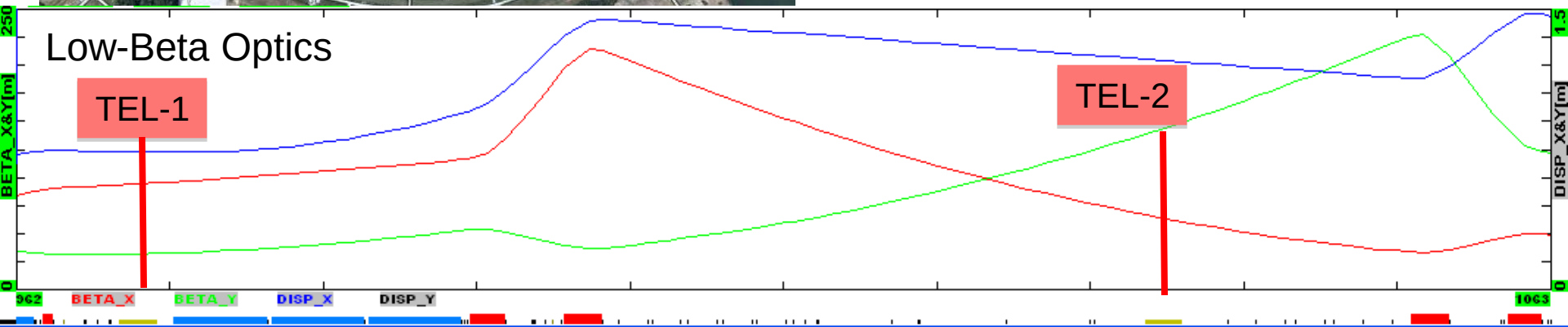
Outline

- Description of Tevatron electron lenses
- Recent TEL-2 developments
  - Gun modulator
  - Gaussian gun
  - BPM readout
- Head-on beam-beam compensation studies status and plans
- Summary

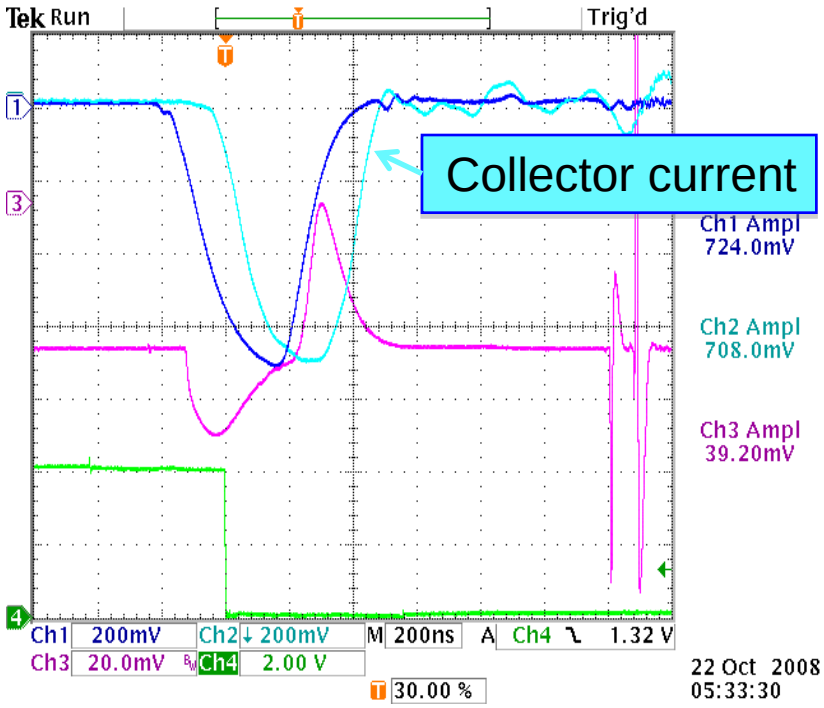
Tevatron Electron Lenses

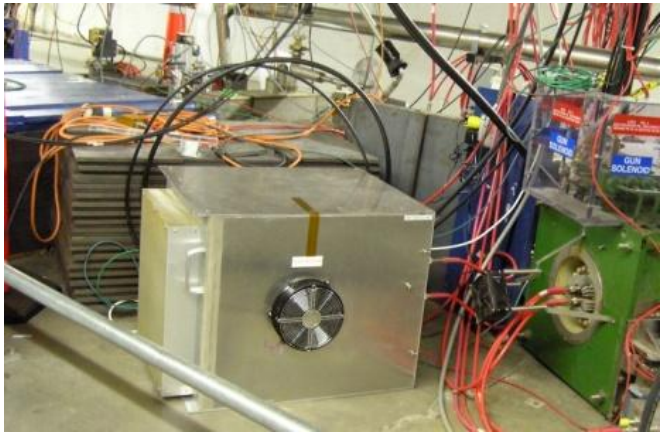


e- beam energy	< 10 kV
Peak e- current	< 3 A
Solenoid B-field	30 kG
Gun B-field	3 kG
e- beam radius (SEFT)	2.3 mm
Interaction length	2 m
TEL-1 βx/βy	95/32 m
TEL-2 βx/βy	66/160 m

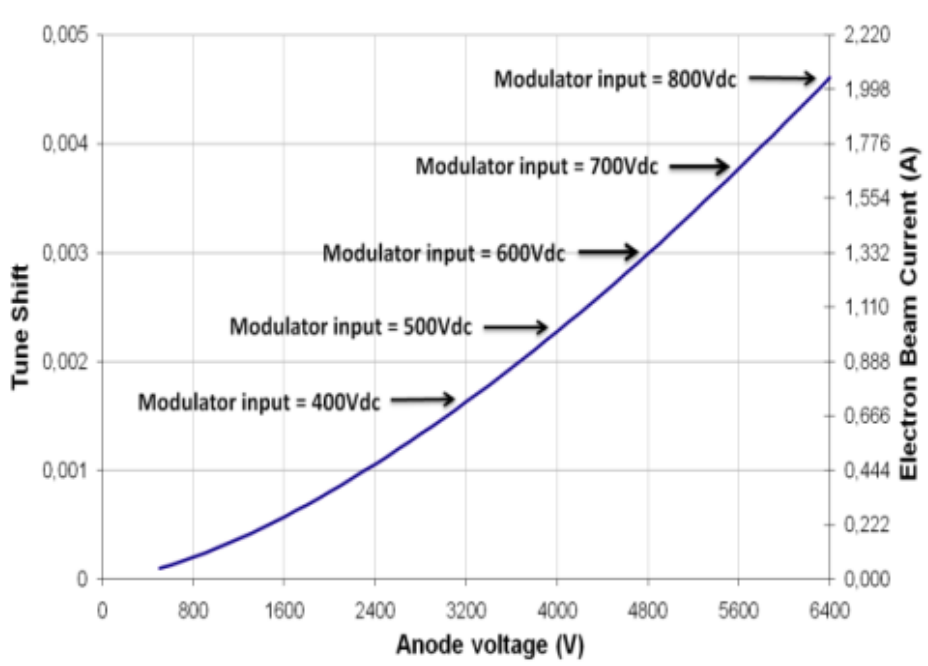


Stacked Transformer Modulator

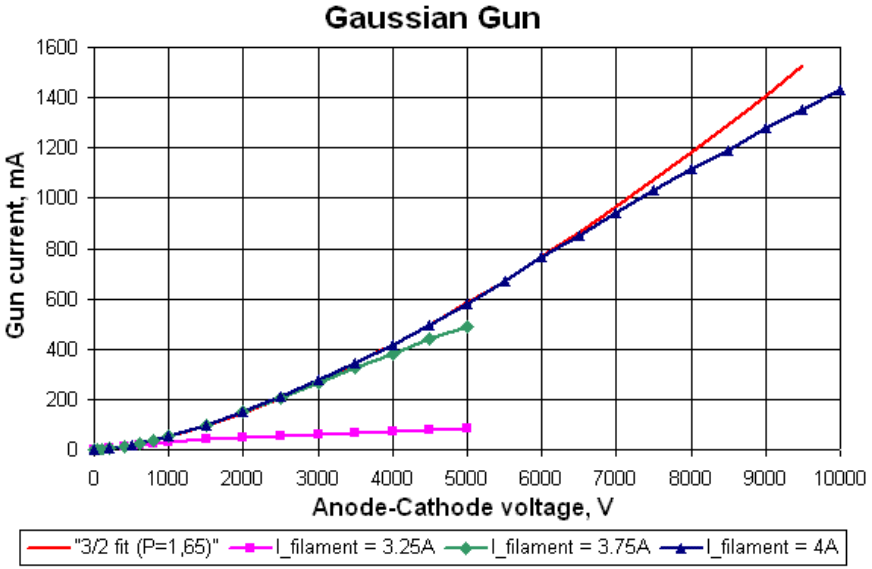


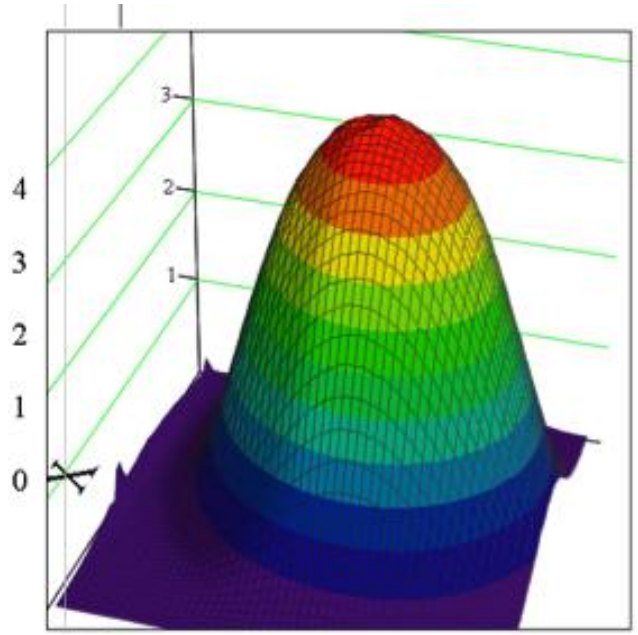


- Output voltage up to 6.5 kV
- Ability to act on individual bunches (bunch spacing 395 ns), highly configurable
- Low ripple flattop

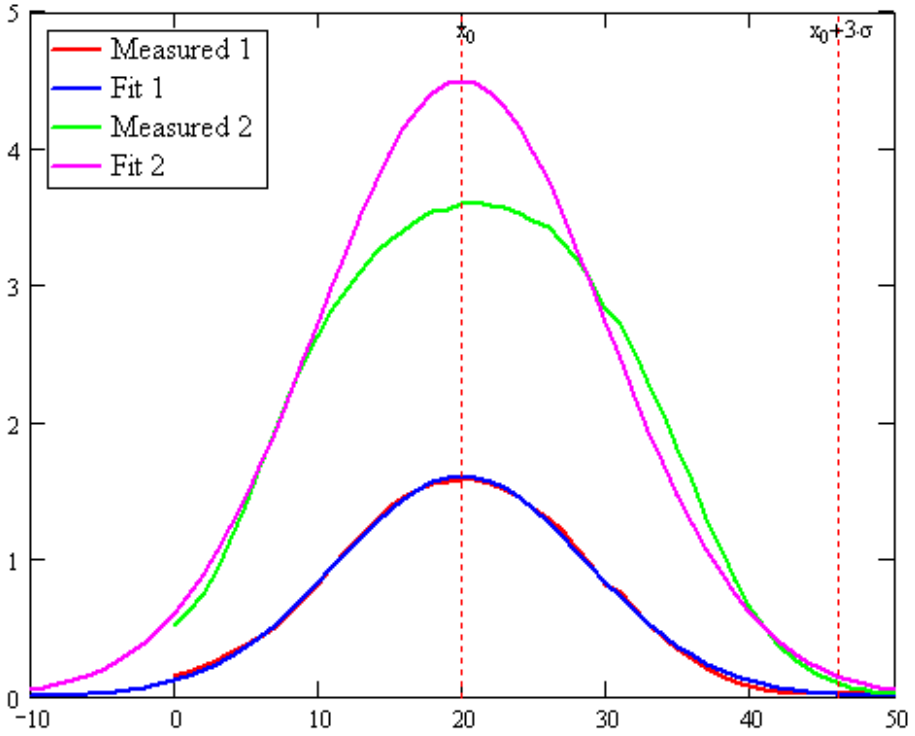


Gaussian Gun

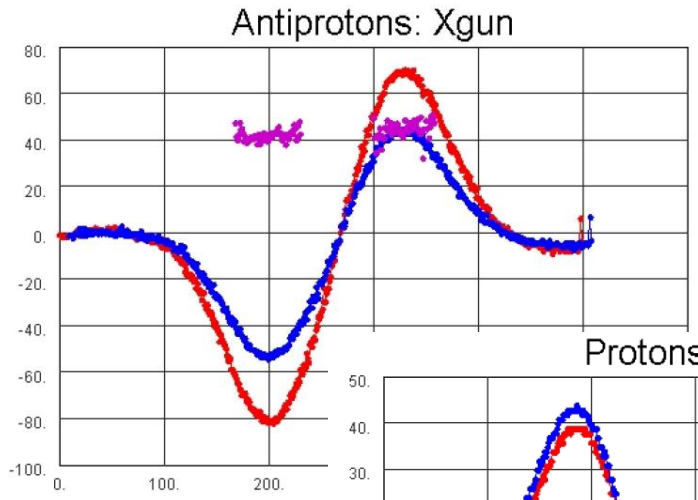


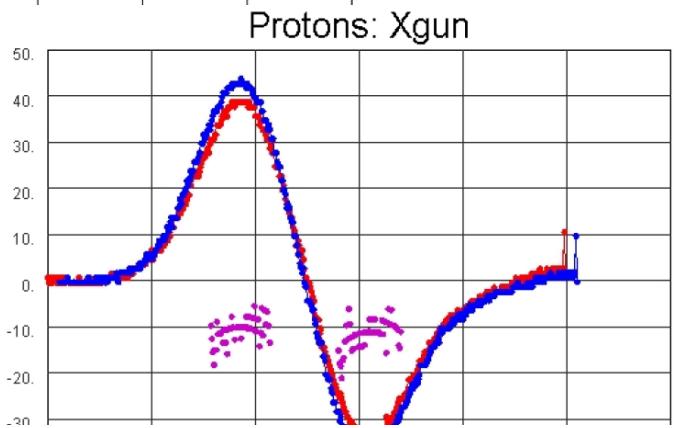


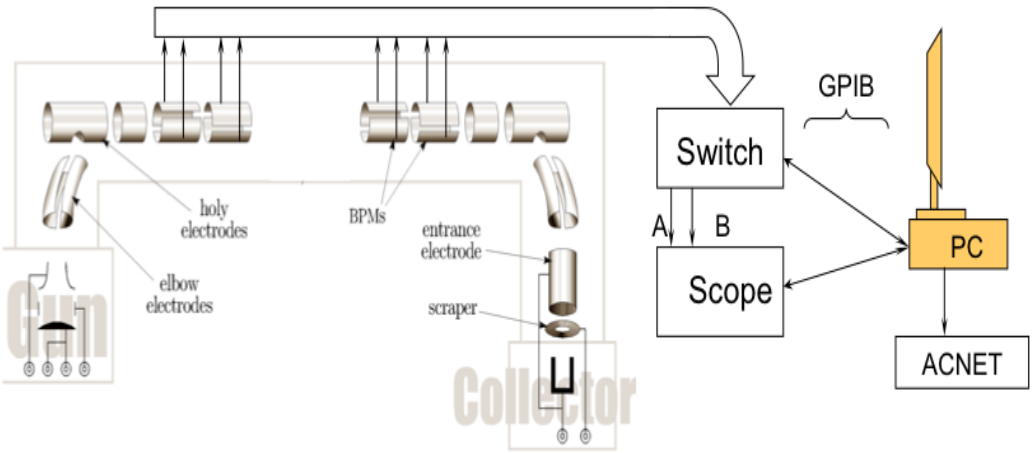
- Up to 1A current with the new modulator (N_e=2x10^{11})
- Installed in TEL-2 on June 20 (Tevatron shutdown 6/15 – 9/11)



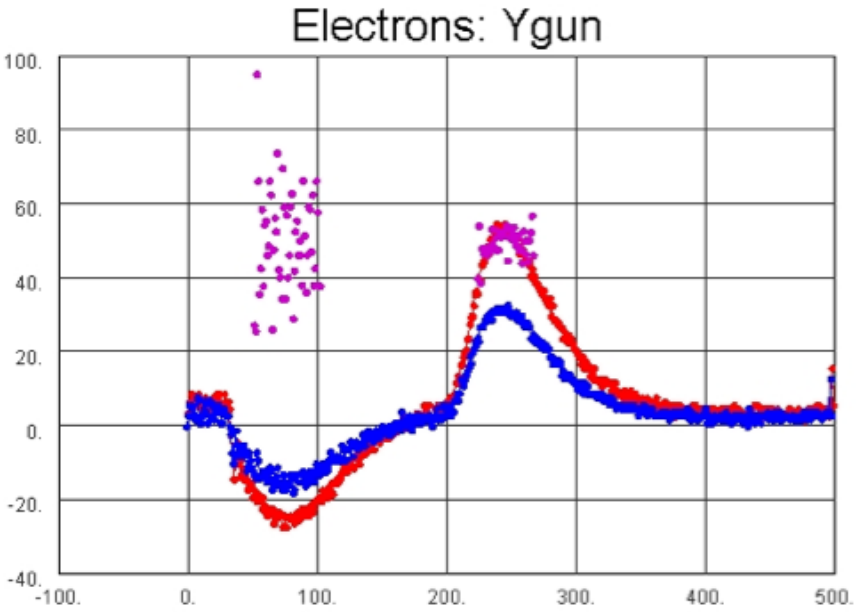
BPM Readout



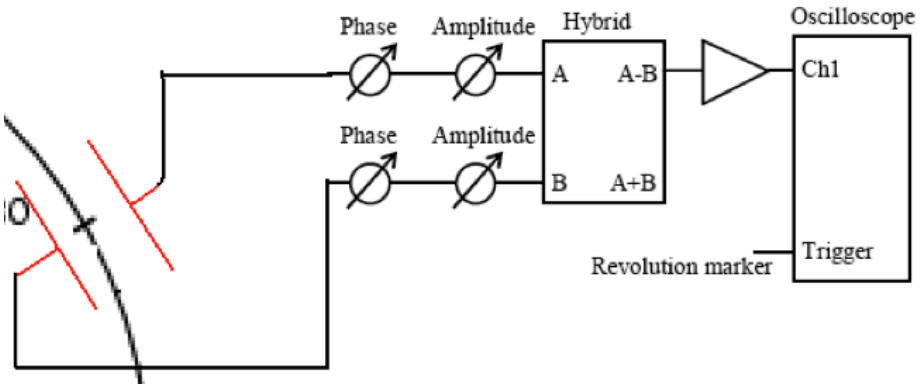




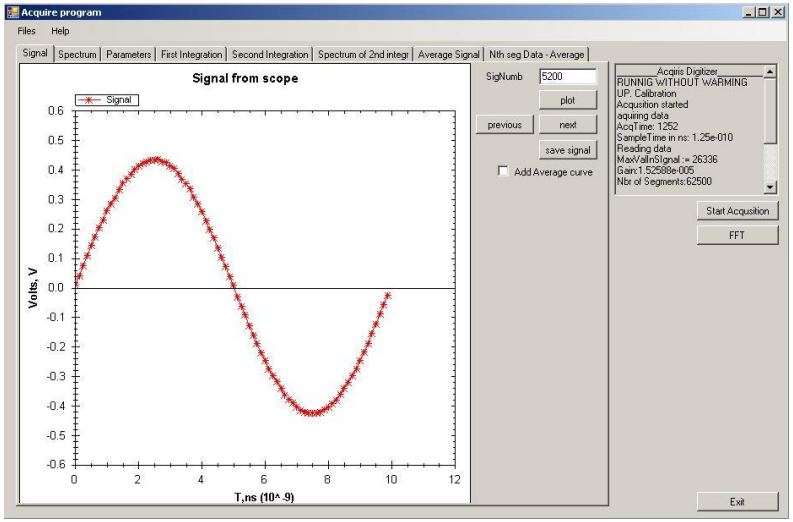
- Old LabView program slow
- New Java program faster (response time ~20 s), uses simpler algorithm
- Shorter e- pulse with new generator – closer calibrations and offsets for electrons and protons/pbars

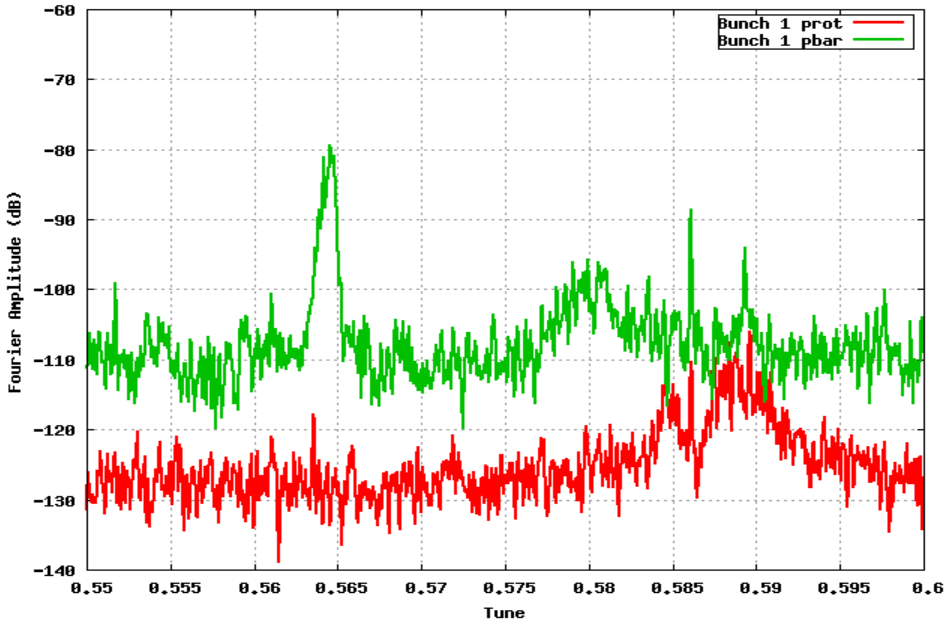


High Resolution Tevatron BPM



- High-resolution turn-by-turn BPM for observation of tune spectra – the goal is to measure tune spread
- Resolution of 0.5-1 μm
- 31,000 turns memory





Study Plan and Beam Time Requirements

- Calibrate BPMs with electrons and protons

  2 hours proton only – done!

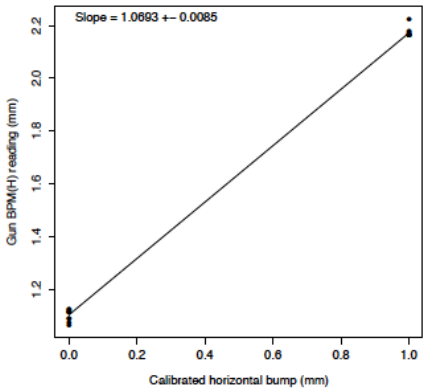
- Align electron beam with protons

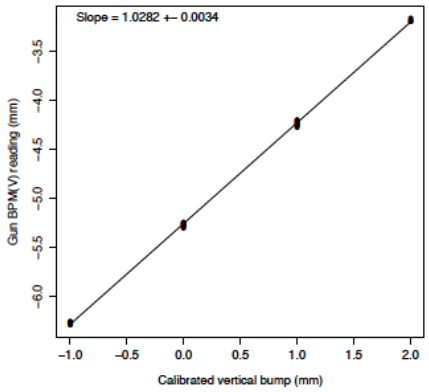
  4-6 hours proton-only – done (used only 2 hours)!

- Measure tune-spread changes, effect on beam life time

  2 hours end-of-store, 4-6 parasitic in-store studies

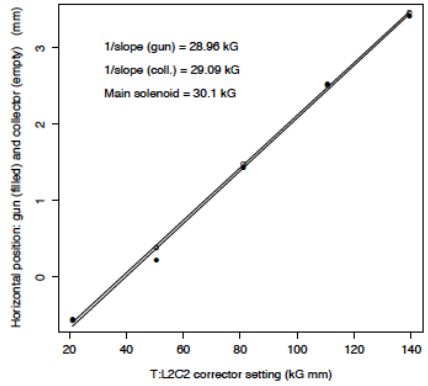
BPM Calibration

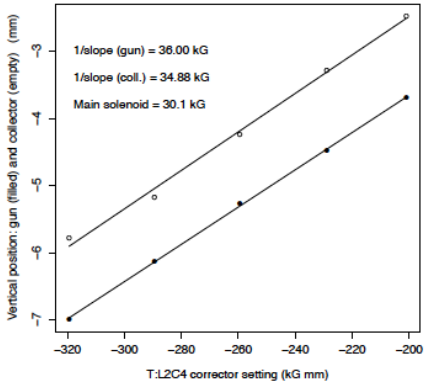




Observable	Measured / Expected Slopes
Δx gun (mm)	1.07 ± 0.01
Δx coll. (mm)	1.03 ± 0.01
Δy gun (mm)	1.028 ± 0.003
Δy coll. (mm)	1.031 ± 0.004
$\Delta x'$ (mrad)	1.10 ± 0.06

TEL-2 BPM calibration with proton beam (closed orbit bump)

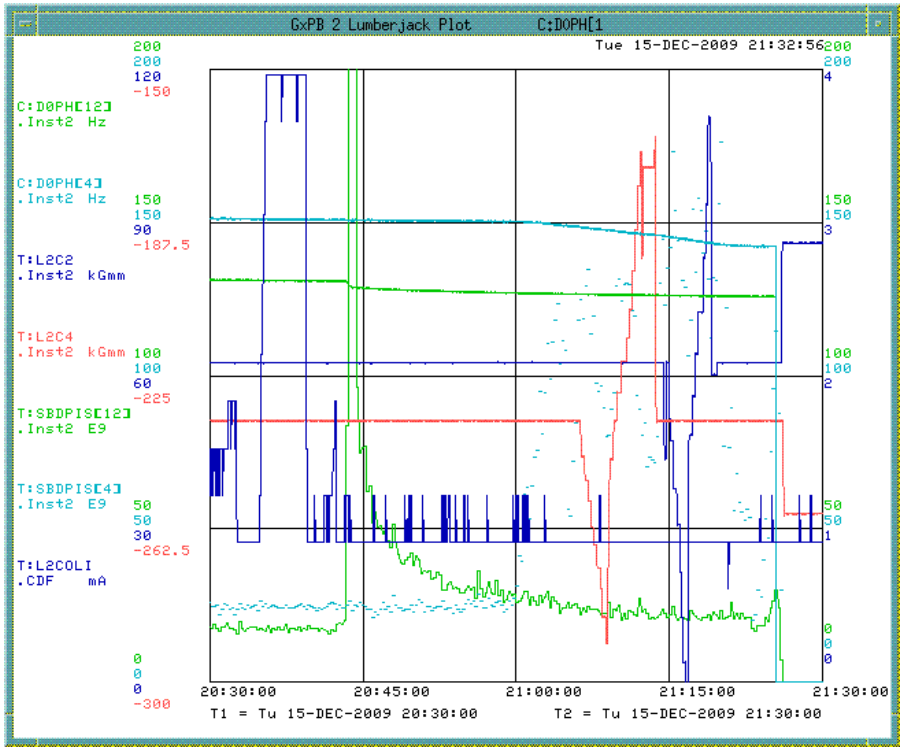


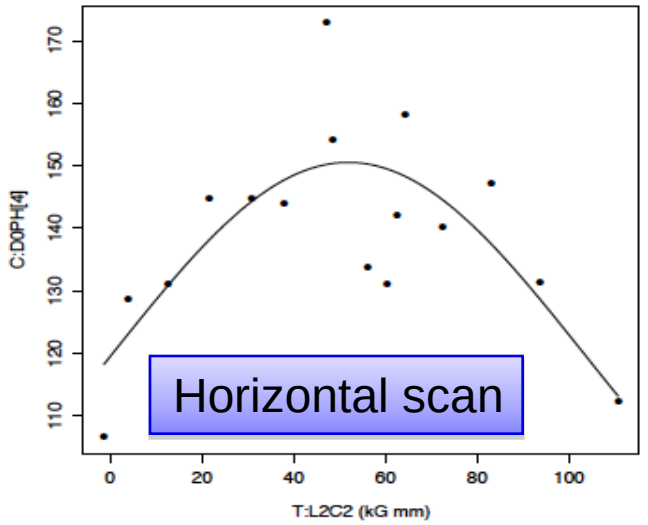


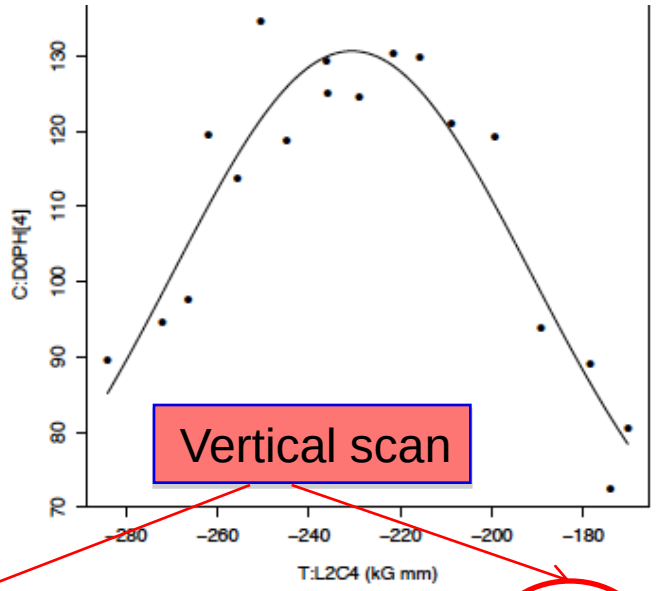
Observable	Measured / Expected Slopes
Δx gun (mm)	1.04 ± 0.04
Δx coll. (mm)	1.03 ± 0.01
Δy gun (mm)	0.84 ± 0.01
Δy coll. (mm)	0.86 ± 0.04

TEL-2 BPM calibration with electron beam

Proton and Electron Beam Alignment







$$\sigma^{e}_{x,y} = (1.67\ \text{mm})\sqrt{\frac{(2.86\ \text{kG})}{(30.1\ \text{kG})}} = 0.52\ \text{mm}.$$

$$\sigma^{p}_{x} = 0.60\ \text{mm} \quad \sigma^{p}_{y} = 0.89\ \text{mm}$$

$$\sigma^{\bar{p}}_{x} = 0.44\ \text{mm} \quad \sigma^{\bar{p}}_{y} = 0.64\ \text{mm}$$

$$\sqrt{(\sigma^{e}_{x})^2 + (\sigma^{p}_{x})^2} = 0.79\ \text{mm} \qquad \sqrt{(\sigma^{e}_{y})^2 + (\sigma^{p}_{y})^2} = 1.03\ \text{mm}$$

$$\sigma = \frac{(39 \pm 25\ \text{kG mm})}{(35\ \text{kG})} = 1.1 \pm 0.7\ \text{mm}$$

Summary

- Head-on beam-beam compensation studies with TEL-2 Gaussian beam are in progress
  - First attempt to align proton and electron beams was very successful owing to the much improved modulator and diagnostics
- Further goals are
  - Observe effect of the Gaussian e- beam on proton/pbar tune spread (expect $\delta Q=0.008$ at 1A)
  - Demonstrate that HO BBC does not lead to life time degradation
  - Study effects of various imperfections